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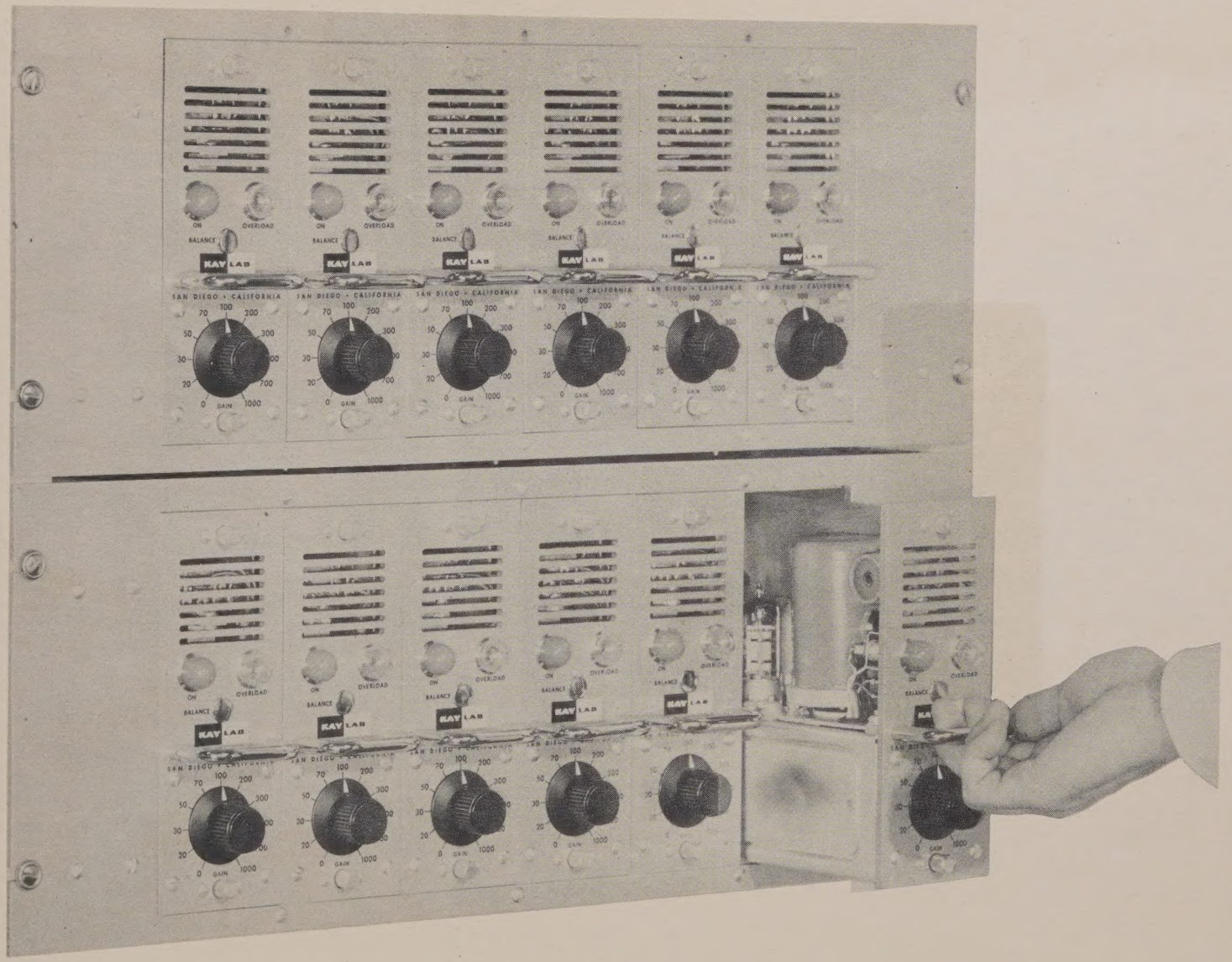
ELECTRONICS FOR COMMUNICATION • MEASUREMENT • CONTROL

KAY LAB

5725 KEARNEY VILLA ROAD, SAN DIEGO 12, CALIFORNIA

TECHNICAL MANUAL
DC AMPLIFIER
MODEL 111

KAY LAB 5725 Kearney Villa Road, San Diego 11, California



MODEL 111 AMPLIFIERS IN 6-UNIT RACK-MOUNTED MODULES

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X-500-8-56

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MODEL NO. 111

CHANGE NO.	TITLE	INITIAL

NUMBER OF LAST CHANGE APPLICABLE TO THIS MANUAL 1

SECTION 1

GENERAL

1.1 DESCRIPTION

The Model 111 DC Decade Amplifier is a high gain, wide band, DC Amplifier specifically designed to accept a small DC voltage from a strain gage or other electro-mechanical device and amplify this signal, providing a voltage output which can be used to drive conventional recording potentiometers or voltmeters. A large amount of feedback provides a very precise and stable gain.

1.2 SPECIFICATIONS

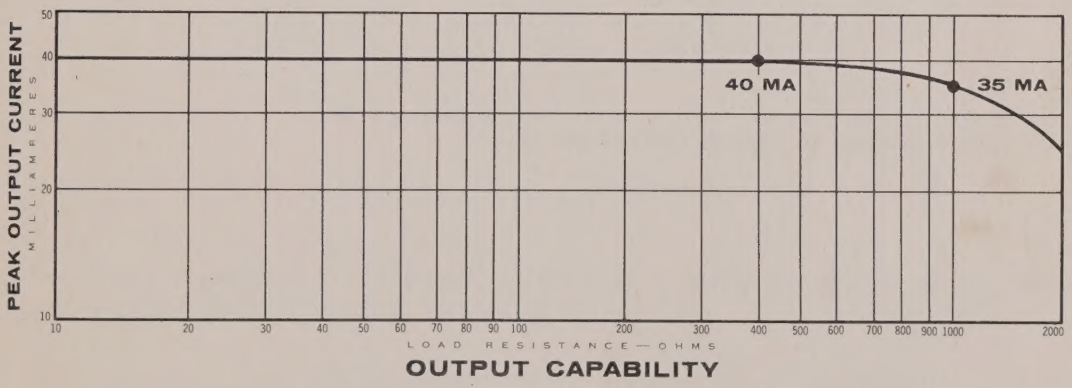
Gain. . . . . Adjustable by switch on front of instrument to steps of: 0, 20, 30, 50, 70, 100, 200, 300, 500, 700 and 1000

Gain Accuracy . . . . . ±1%, DC to 2 KC

Input Impedance . . . . . 100,000 Ω

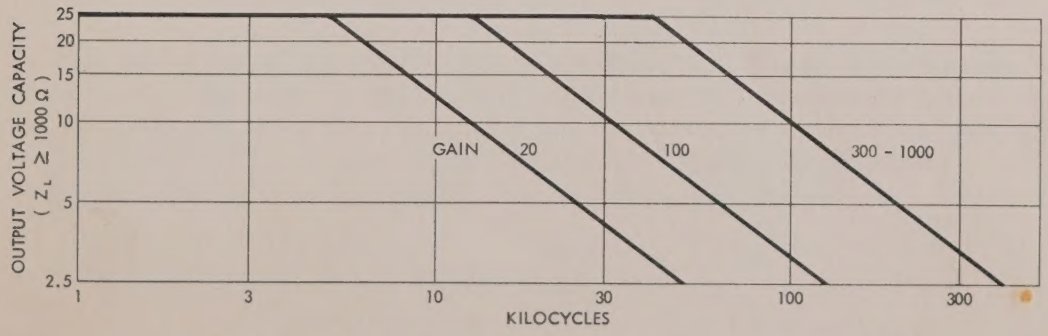
Output Impedance . . . . . Less than 1 Ω in series with 25 μh

Output Capability-DC . . . . . See graph below



OUTPUT CAPABILITY

Output Capability-AC . . . . . See graph below



Maximum Output Cable Capacity .	0.02 μf (external)
Equivalent Input Drift	±3 μv when used with regulated line. ±10% change in line causes ±5 μv change. 10-minute warm-up period required.
Equivalent Input Noise	0 to 3 cps, less than 5μv PP 0 to 750 cps, less than 5 μv RMS 0 to 50 kc, less than 12 μv RMS
Chopper Intermodulation	Less than 0.1%
Linearity	Better than 0.1% to 2 kc
Frequency Response	0.3db (±3%) DC to 10 kc, less than 3 db down at 40 kc
Phase Shift	Less than 5° to 2 kc
Power Required.	117V at 0.70 amperes
Dimensions:	
Amplifier Unit	2-7/8" wide, 7-5/8" high, 14-5/8" deep
Cabinet for single amplifier . . .	5-7/16" wide, 10" high, 18-1/2" deep
Rack adaptor for 6 amplifiers . .	19" wide, 8-3/4" high, 18-1/4" deep
Net Weight	11 pounds
Shipping Weight	19 pounds

Specifications subject to change without notice.

SECTION 2

CIRCUIT DESCRIPTION

2.1 CIRCUIT THEORY, FEEDBACK AMPLIFIERS

The purpose of the amplifier is to give a precise, known gain. Such a requirement implies the use of feedback for gain stabilization.

2.1.1 General Gain Equation (See Figure 2.1)

The general gain equation for feedback amplifiers of this type is:

$$g = \frac{e_o}{e_i}\Big|_{i=o} = \frac{-aR_2 + Z_o}{(1+a)(R_1 + Z_s) + \left[\frac{R_1 + Z_s}{Z_g}\right](R_2 + Z_o)}$$

if $Z_g \gg R_1 + Z_s$

$R_2 + Z_o \ll (R_1 + Z_s)\ (1 + a)$

$a \gg 1$,

then $g \approx -\frac{aR_2 + Z_o}{a(R_1 + Z_s)} = -\frac{R_2}{R_1 + Z_s} + \frac{Z_o}{a(R_1 + Z_s)}$

usually $R_1 + Z_s \geqq Z_o$ and $a \gg 1$

Therefore $g \approx -\frac{R_2}{R_1 + Z_s}$

This makes it evident that in order for variations in source impedance to have little effect on the gain, Z_s must be very much less than R_1.

Reference: Radiation Laboratory Series, Volume 18, pages 335-336.

2.1.2 Attenuator Feedback (See Figure 2.2)

In addition to the resistive mixing type of feedback circuit used, an attenuator is also used to allow the amplifier gain to be controlled without changing the input resistor. In this system the attenuator is placed across the output and a switch may then select a fixed portion of the output voltage, depending on the attenuator setting.
If $R_2 \gg R_4$, the case for this system, then the attenuator gain will be: $\frac{R_3}{R_3 + R_4}$

and the overall amplifier gain will be:

$$g \approx \left(-\frac{R_2}{R_1 + Z_s}\right)\left(\frac{R_3 + R_4}{R_3}\right)$$

2.2 CIRCUIT THEORY, INTERNAL AMPLIFIERS

Since the system is to amplify DC, chopper or direct coupled amplifiers must be used.

2.2.1 Chopper Amplifiers, Basic Principles

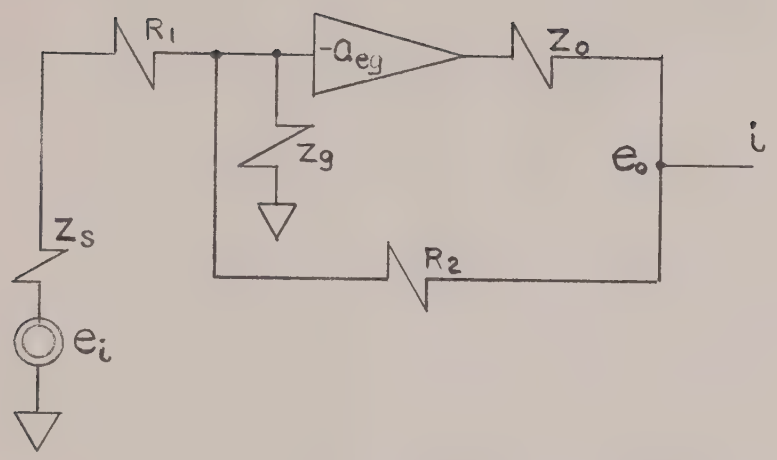
For the amplification of DC, a chopper amplifier is provided. This amplifier consists of a mechanical chopper which converts any DC input to a proportional AC using a carrier frequency of 60 cycles per second. This carrier signal is then amplified by a narrow band, high gain RC coupled amplifier. The output is synchronously rectified to produce a proportional DC output. Thus the spurious DC voltages common in directly coupled DC amplifiers are reduced to negligible values. In a direct coupled DC amplifier, small voltages due to electrochemical action between metal surfaces, minute unpredictable voltages developed by grid currents all tend to produce drift and an output voltage with zero input voltage. Thus direct coupled amplifiers cannot be used effectively where the input signals are comparable to such spurious voltages.

2.2.1.1 The principle of a typical chopper amplifier may be described as follows: (See Figure 2-3).

The amplifier may consist of a number of simple RC coupled stages. Whether or not a phase reversal occurs in the amplifier will depend upon the number of stages and the chopping sequence. One pole is used for input chopping, the other for output, so connected in this case that the output capacitor (C2) is shorted to ground when the input grid is open, and vice-versa. Under no-signal equilibrium conditions, the input contacts do nothing. On alternate half cycles capacitor C2 is connected to ground, charging it to a static plate voltage of the output stage.

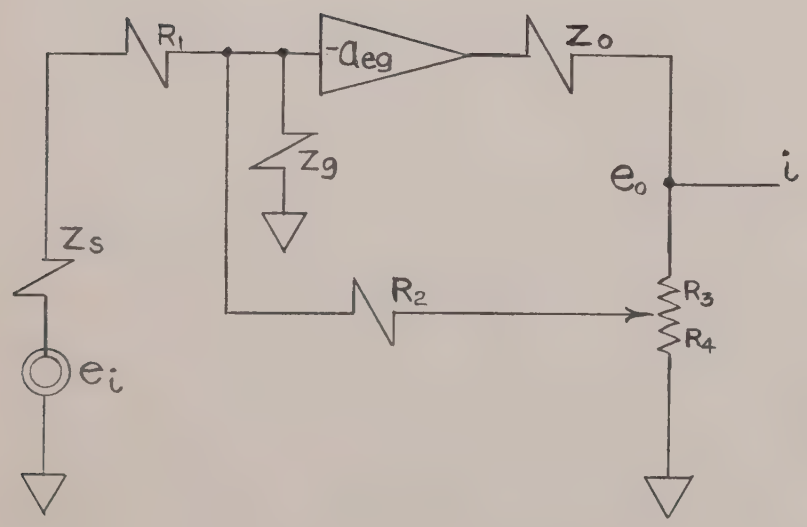
2.2.1.2 Except for negligible leakage, C2 remains charged to this voltage during the other half cycles when it has a path to the filter (R1-C3). Half of the time, the input voltage to the filter is then zero, and during the other half it is equal to the plate voltage of the output stage, less the voltage drop in C2. With no input, the drop in C2 equals the plate voltage and no signal is applied to the filter.

2.2.1.3 Now assume that a positive DC signal is applied during the time the input contacts are closed. This signal is represented as a battery and current-limiting resistor. No signal reaches the amplifier, and the voltage on C2 is unchanged. This condition remains until the contacts switch. At this time, the input grid and the output plate go more positive. C2 now charges to the higher voltage while the input to the filter is shorted. At the end of this half cycle the input grid returns to normal as does the output plate. However, the input to the filter is not zero, but sees the normal plate voltage of the output stage, less the drop in C2, which is now greater, resulting in a negative input to the filter. During the next half cycle, the output plate voltage will again be higher than normal if the positive DC signal is still present. Had the input signal been negative, the output plate voltage would have been lower than normal during the charging period of C2. This would have caused a positive input to the filter in the same manner as before.



RESISTIVE MIXING FEEDBACK

Figure 2.1



FEEDBACK ATTENUATOR
AND
RESISTIVE MIXING FEEDBACK

Figure 2.2

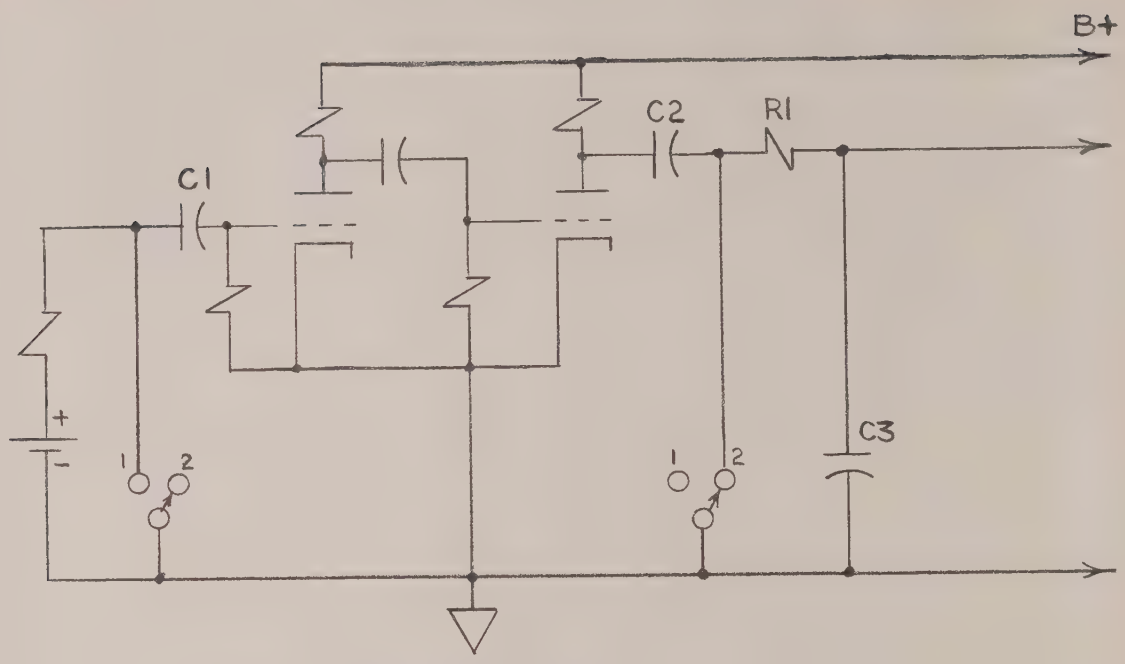


FIGURE - 2.3

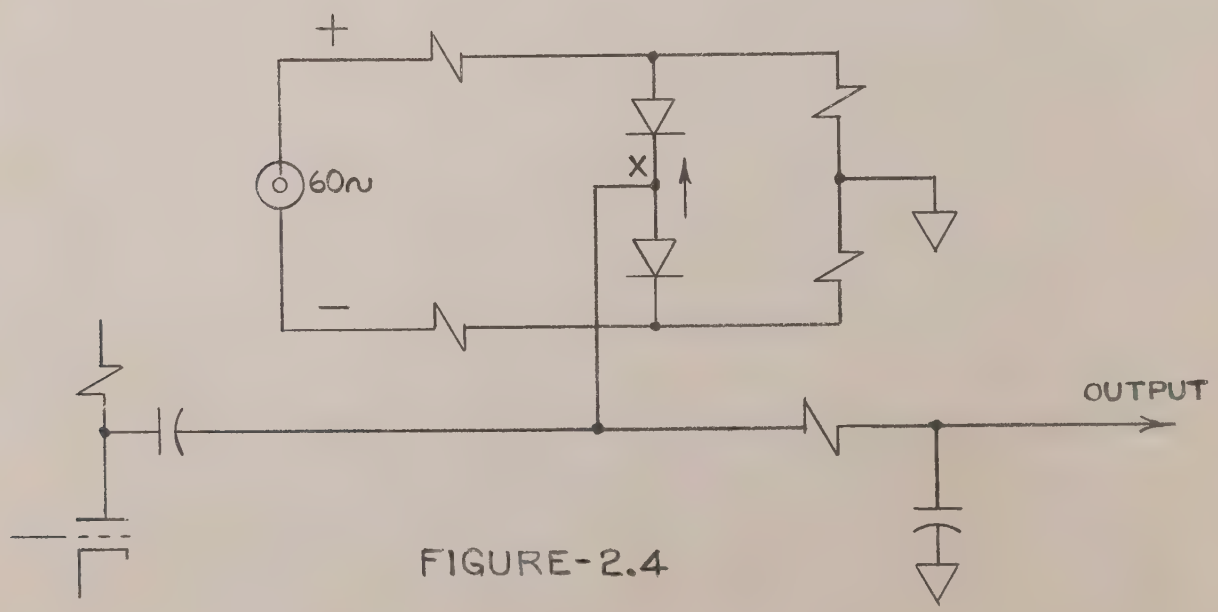


FIGURE - 2.4

2.2.1.4 In the basic system described by Figure 2.3, only two stages are shown. Thus, because of the inversion added by the chopper, the output is phase inverted; a positive signal input results in a negative signal output. By the addition of another stage, the signal can again be inverted resulting in zero overall phase shift. The actual circuit used in the Model 111 amplifier consists of two stages, an inverted signal output, then an additional stage, another synchronous rectifier and a non-inverted output. The two outputs are fed to different summing junctions in the proper phase. See Figure 2.5, Schematic Drawing D987465, paragraphs 2.3.2, 2.3.3, 2.4.2 and 2.4.3.

2.2.1.5. As an alternative to synchronous output rectification a driven diode network might be used as indicated in Figure 2.4. When the polarity of the 60 cycle voltage is as indicated, maximum electron conduction takes place through the diodes and the point (x) becomes essentially at ground potential, thus having the same function as a ground through a chopper. When the voltage is the reverse of that indicated, the diodes do not conduct, and the point (x) is essentially isolated from ground.

2.2.2 AC Amplifiers

To pass the AC portion of any signal input (changes in DC input signal) with sufficiently rapid response, broadband AC Amplifiers are used. These amplifiers work in conjunction with the DC chopper amplifiers in such a manner as to produce an overall response which is essentially flat from zero cycles to several thousand cycles with no roll off and no phase shift as the frequency approaches DC.

2.3 BLOCK DIAGRAM OF THE SYSTEM

2.3.1 General

The frequency response of chopper amplifiers is typically limited to approximately 20% of the chopping frequency. Since the frequency response of the 111 must be much better than this, the chopper amplifier is bypassed with a high frequency amplifier. A very basic block diagram of the 111 is shown in figure 2-5. As shown in this illustration, frequencies above some several cycles are amplified by a high-frequency amplifier, and very low frequencies and dc are amplified by a low frequency (chopper) amplifier. The output of both the high and low frequency amplifiers is combined in a summing junction and applied to an output amplifier which supplies the requisite power.

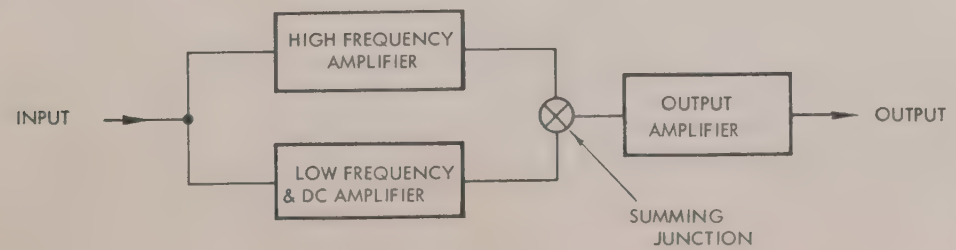


FIGURE 2-5

BASIC BLOCK DIAGRAM OF MODEL 111

2.3.2 High Frequency Signal Path

A more complete block diagram of the 111 is shown in Figure 2-6. Frequencies greater than several cycles are passed through the high frequency amplifier which consists primarily of V303A and V304. From V304, the high frequency signal is applied through C310 to summing junction J2, where it is summed with the low frequency and d-c signal from the chopper amplifier. From the summing junction, the combined signal is direct coupled to V305. The signal is amplified in V305 and again direct coupled to the output stage. One internal feedback loop, L1, stabilizes the gain of V305 and the output stage and places the point of critical phase shift at a frequency where gain is not sufficient to cause instability, which avoids the possibility of oscillation. Overall gain stability is provided by feedback loop L2.

2.3.3 Low Frequency and DC Signal Path

The primary path of very low frequency and d-c signals is through the chopper amplifier, which consists of D301, V303B, V308, CR303 and CR 304. After chopping, the input signal is applied to input stage V303B, which is a low-noise amplifier. From V303B the low frequency and d-c signal is coupled to V308A where it is further amplified. The signal from V308A is applied to V308B and is then synchronously rectified by CR303 and CR304. The resultant signal is applied to summing junction J2 where it is combined with the high frequency signal. From summing junction J2 the combined signal is direct coupled to V305 from where it is again direct coupled to the output stage. Since direct coupling only is used beyond summing junction J2, d-c sense is maintained. In order to provide increased amplifier stability, a portion of the low frequency signal is taken from V308A and applied to summing junction J1.

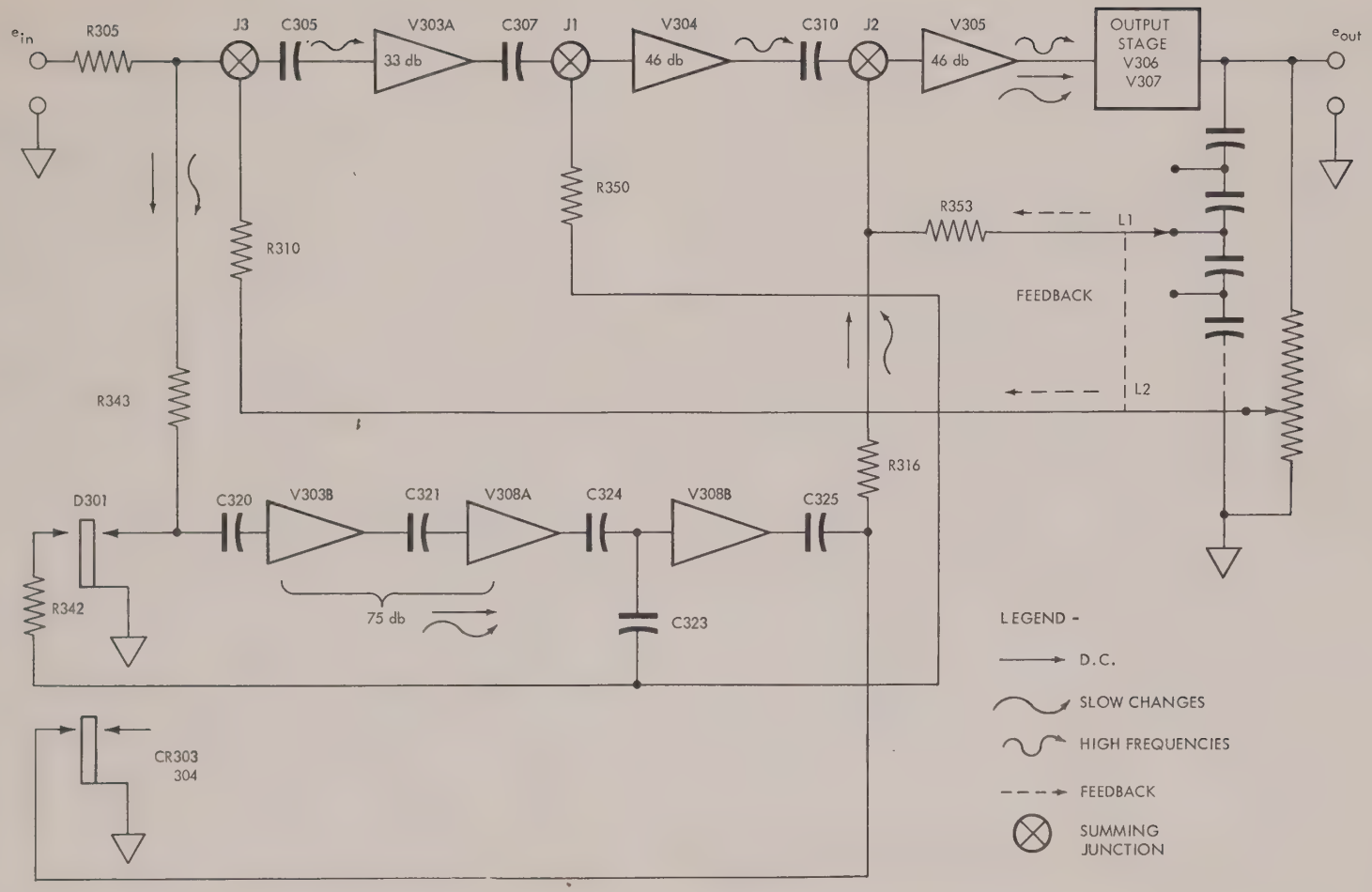
2.3.4 Output Amplifier

The output stage is a d-c amplifier which consists of four triodes connected in a bridge circuit. In this type of circuit, the conductance of the triodes may be varied in such a way as to vary the current through the load without changing the current requirements of the power supply.

2.4 DETAILED CIRCUIT DESCRIPTION

2.4.1 High Frequency Signal Path

See schematic diagram D987465. The input signal is applied to pins 11 and 12 of the Cannon connector at the rear of the amplifier chassis. The high frequency signals are applied through C305 to the grid of the first amplifier stage, V303A. The signal from V303A is then coupled through C307 to the grid of V304. Here the high frequency signals are joined by the d-c and low frequency signals from V308A in the chopper amplifier. This point in the circuit constitutes the previously described summing junction, J1. The output of V304 is coupled through C310 to the input grid of V305. In addition, the output of the chopper amplifier from V308B is coupled through R316 to the grid of V305; and the signal from feedback loop L1 is coupled through R358 to the grid of V305. The input grid of V305, where these three signals are applied, constitutes summing junction J2 The signal from V305 is then direct coupled through R320 to the output amplifier.



MODEL 111 AMPLIFIER BLOCK DIAGRAM FIGURE 2.6

2.4.2 Low-frequency and d-c Signal Path

Low-frequency and d-c signals are fed from the input through R343 to chopper D1. The chopper converts the input signal to a proportional 60-cycle a-c signal. The proportional signal is coupled through R344 and C320 to the control grid of V303B. The signal from V303B is coupled through C321 to the input grid of V308A. The signal from V308A is coupled through C324 and R355 to the control grid of V308B. The output of V308B appears at C325 where it is sampled every half-cycle by a synchronous rectifier consisting of CR303 and CR304. This network consists of two diodes connected so their center point corresponds in potential to the junction of R312 and R313 or ground when the diodes are conducting. The conduction state of the diodes is determined by a 60-cycle driving voltage derived from the secondary of T301. When the driving voltage is such that the diodes do not conduct, the junction between the two diodes is isolated from ground. Thus the two diodes perform the same function as a mechanical chopper; i.e., to alternately ground and leave open a particular point in the circuit. The rectified output of the chopper amplifier is applied through R316, which also serves as a grid return for V305, to the control grid of V305. Bias cell BT301 provides bias for the control grid of V305. The signal from the chopper amplifier, the signal from feedback loop L1, and the signal from the high frequency amplifier are all combined at the control grid of V305, which is summing junction J2. The combined signal is amplified by V305 and then direct coupled through R320 to the output amplifier. A portion of the proportional a-c signal from V308A in the chopper amplifier is synchronously rectified by chopper pin 5 and applied, along with the bias voltage developed by BT302, through R349 and R350 to summing junction J1. As previously stated, the purpose of this is to provide increased amplifier stability.

2.4.3 The DC Output Amplifier Circuit

See Figure 2.6. The output circuit consists of a balanced 4-tube circuit arranged in a form somewhat similar to a bridge with the load placed across the bridge in the position normally occupied by a null indicator. The purpose of this arrangement however, is to provide a balanced output which is capable of a full range of current through the load in either direction. The bridge circuit is so arranged that the total current drawn from the power supply remains constant with signal fluctuations. It is also important to note that the stage is supplied with its own independent power supply with B-floating and not associated with circuit ground except indirectly through the conductance of the tubes.

The direction and magnitude of the current through the load depends upon the relative impedance of the four arms of the bridge. This relative impedance in turn depends upon the signal input at the control grid, pin 1, of V306.

The main purpose of the various resistances used in the circuit is to provide appropriate attenuation of signals being carried to the control grids to match the natural gain of each tube.

The sequence of operation is as follows:

Suppose a positive signal is applied to the control grid, pin 4 of V306A. This will tend to cause the plate current of V306A to increase and the plate voltage to decrease. The attenuator composed of R326 and R329 then couples a portion of this change to pin 1 of V306B. This will tend to cause the plate current of V306B to decrease and the plate voltage to increase.

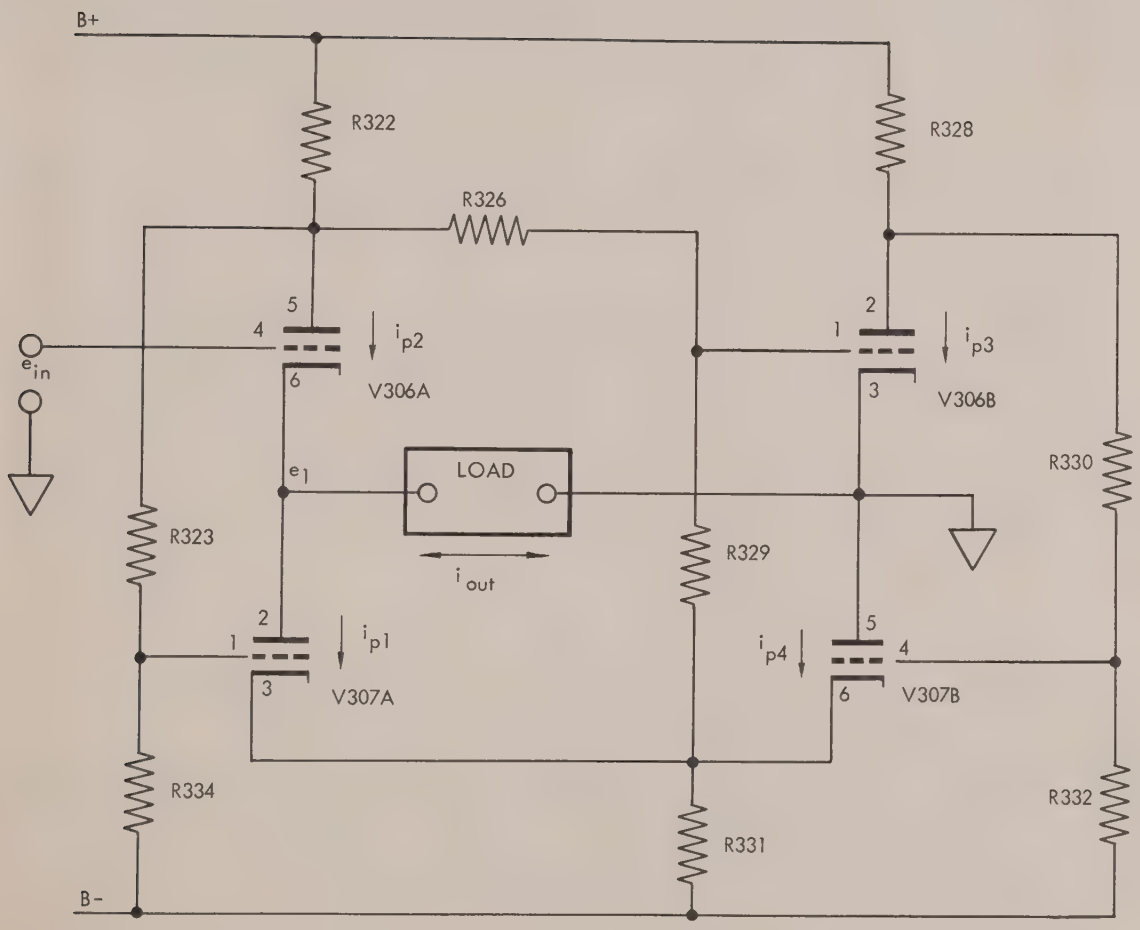

B+
R322
R328
R326
5
4
6
V306A
i_{p2}
2
1
3
V306B
i_{p3}
e_{in}
e_1
LOAD
i_{out}
R330
R323
R329
2
1
3
V307A
i_{p1}
i_{p4}
5
4
6
V307B
R334
R332
R331
B-

FIGURE 2.7

The plate voltage decrease of V306A is also coupled through the attenuator, R323 and R334, to pin 1 of V307A. This tends to cause a decrease in the plate current of V307A. The plate voltage increase of V306B is likewise coupled through the attenuator, R330 and R332, to pin 4 of V307B, which tends to increase the plate current.

The output stage may now be examined under the above condition and it will be found that although the plate current of V306A has increased, the plate current of V307A has decreased, therefore, the plate current of V306A must be composed of an additional current whose only path can be through the load. The operation of V306B and V307B at very low frequencies, is the same as V306A and V307A. A ground connection may be made to furnish load current referenced to ground.

At higher frequencies the feedback paths of V306B and V307B are bypassed and serve only as a current path to ground.

2.4.4. The Attenuator Circuit

A step attenuator is used for overall feedback. The attenuator consists of a string of resistors, R412 through R423, having a total nominal resistance of 9000 Ω. The gain is determined by the position of the switch and the value of $(Z_S + R305) + R306$ or $(Z_S + R1) + R2$ of the simplified circuit of Figure 2.1. For example, consider the 100X gain position. Under this condition, the sum of resistance between the tap and the output terminal is 8100 Ω and the sum of the resistance between the tap and ground is 900Ω. The value of R306, the feedback resistor, is 1-megohm and R305, the input resistor is 100K. Now if the source impedance (Z_S) is zero, then the gain will be

$$G = \frac{8100 + 900}{900} \times \frac{10^6}{10^5} = 100$$

An additional network is provided for high frequency feedback through C401 to C410 and associated resistors. This network is switched with changes in gain to maintain a constant frequency response on all gain settings. With an increase in feedback, the normal tendency is to increase bandwidth. With low gain and a large amount of feedback, the bandwidth might otherwise increase to the point where critical phase shift could cause instability and oscillation By keeping the high frequency cut-off point always below the frequency at which critical phase shift occurs, this network then insures stability on all gain ranges.

In addition, the network R306 and C304 provides a controlled linear phase shift characteristic over the pass-band which is desirable for correct transient response.

2.4.5 Miscellaneous Circuit Features

2.4.5.1 Heater Circuits: It should be noted that certain tube heaters are supplied with DC by CR301 and CR302.

2.4.5.2 Chassis Ground, Circuit Common: See Schematic Drawing D987465. It should be noted that the chassis ground pin 4 and circuit common pin 1 are both brought out to the Cannon Connector, P301. The purpose of this arrangement is to allow all grounds from devices associated with the Model 111 amplifier in a particular

system to be brought out to a common point. Such a practice will insure an equal potential of all such circuits at low frequencies for reasonable lead lengths and wire diameters.

At high frequencies, due to transmission line effect, the lead lengths involved in bringing such circuits to a common point may be such as to reflect an unsuitably high impedance between circuit common and chassis ground. To insure that the impedance does not rise to a large value, a 4.7Ω resistor and a .01 μf capacitor (R354 and C319) are connected between circuit common and chassis ground.

SECTION 3

OPERATION

3.1 GENERAL

The KAY LAB DC Amplifier, Model 111 may be used with two types of packaging. When one unit is to be used alone, the amplifier will normally be installed in a cabinet designed to contain a single unit. The single cabinet is equipped with a line cord at the rear and front panel terminals for input and output. Where amplifiers are ordered in multiples of six, a 19-inch rack adaptor module is supplied to hold forced air ventilation. The Model 111 amplifier slides into the receptacle provided and a Cannon connector mates with a connector mounted in the rack adaptor at the rear. In order to operate the units, cabling at the rear will be necessary. Such cabling may be soldered directly to the Cannon connectors in the rack adaptor module. The Cannon connectors in the rack adaptor are readily available at the rear for soldering of connections when a rear gutter plate is removed. Cables may be run along the gutter and through grommeted holes made available at the rear sides, right or left as may be desired. In connecting output leads to the Cannon connector, it should be kept in mind that the maximum output capacity, including cables, may not be more than 0.02 μf.

3.2 OPERATION

The amplifier should be allowed a period of 10-minutes for warmup after it is initially turned on. The gain is then set by means of the switch on the front panel to the particular gain desired. A pilot lamp indicates that the instrument has been turned on. A neon lamp overload indicator provides warning that the output capabilities of the amplifier are on the verge of being exceeded.

3.3 BALANCE

On rare occasions, it may be desired to balance the amplifier. To accomplish this, the input is shorted and the output is adjusted to zero by means of the slotted-shaft balance potentiometer which is located behind a trim-out on the front panel. It should be kept in mind, however, that the zero drift specification over long periods of time is on the order of 2 μv equivalent input, and that in practice the amplifier will drift no more than 1/2 μv from zero. Thus a sufficiently accurate indication of the output voltage is necessary before balance is attempted if accurate results are to be obtained.

SECTION 4

MAINTENANCE

4.1 TROUBLE SHOOTING

In case of failure of the unit, the usual trouble shooting procedure applicable to electronic equipment should be applied. A routine check of all tubes and diodes, and a check of all voltages as indicated on the schematic should be made.

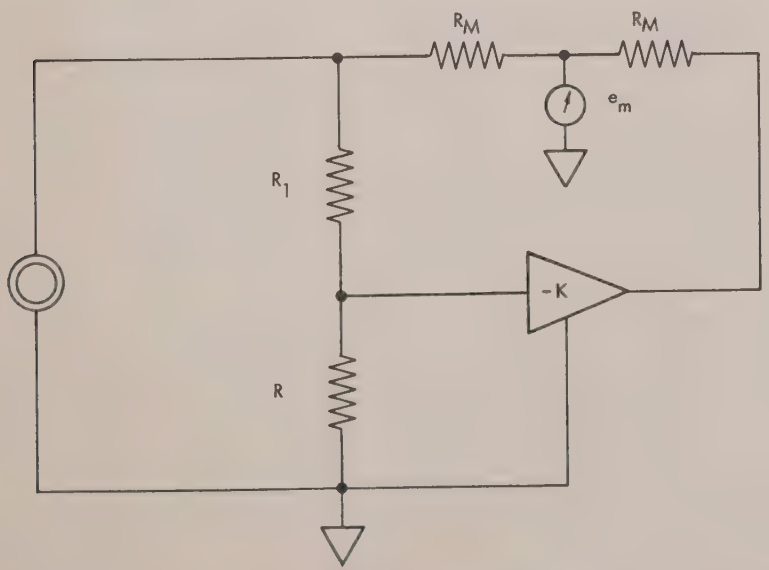
4.2 FAN LUBRICATION

The fan motors in cabinets and modules should be lubricated approximately every six (6) months with light machine oil.

4.3 AMPLIFIER TESTING

The accuracy of the amplifier is such that it cannot be fully tested by ordinary means. To check gain accuracy and phase shift, a special precision bridge will normally be required. Instructions on the bridge should be consulted where such a bridge is used. To insure accurate testing of the amplifier, it is recommended that the KAY LAB Test Bridge be used. This companion unit provides complete test facilities, especially designed to the accuracies necessary for precision testing of the Model 111 amplifier.

Where the KAY LAB Test Bridge is not available, a check of the gain accuracy can be accomplished by means of a precision attenuator. The accuracy of this method is limited only to the precision of the attenuator and the ability of the meter to indicate a true zero.



When $e_m = 0$

$R_m = R_m$

Then

$$\frac{R_2}{R_1 + R_2} = K$$

METHOD OF CHECKING GAIN ACCURACY

FIGURE 4.1

KAY LAB MODEL 111 AMPLIFIER

VOLTAGE AND RESISTANCE CHARTS

All measurements were made from indicated pin to ground with Hewlett-Packard Model 410B VTVM, or equivalent instrument with 100 megohms d-c input resistance. All measurements were made with the input shorted and with the gain set at 1000. All resistance measurements are approximate only.

VOLTAGE CHART

TUBE	Pin Number 1	2	3	4	5	6	7	8	9
V301 6X4	AC	NC	FIL	FIL	NC	AC	+410	NP	NP
V302 6X4	AC	NC	FIL	FIL	NC	AC	+200	NP	NP
V303 5751	+125	-1.35	0	0	0	+125	-1.35	0	+5.2
V304 6AU6	-1.35	0	+12	+5.2	+185	+70	0	NP	NP
V305 6CB6	-1.8	0	FIL	FIL	+145	+74	0	NP	NP
V306 6BX7	-12	+135	0	-10	+135	0	FIL	FIL	NP
V307 6BX7	-125	0	-115	-125	0	-115	FIL	FIL	NP
V308 6AW8	0	-1.35	+90	FIL	FIL	0	-1.35	+24	+155

RESISTANCE CHART

TUBE	Pin Number 1	2	3	4	5	6	7	8	9
V301	400Ω	NC	FIL	FIL	NC	400Ω	80K	NP	NP
V302	130K	NC	FIL	FIL	NC	130K	160K	NP	NP
V303	300K	*	0	0	0	300K	*	0	3Ω
V304	*	0	4.3Ω	3Ω	150K	38K	0	NP	NP
V305	*	0	FIL	FIL	140K	38K	0	NP	NP
V306	170K	160K	0	600K	160K	9K	FIL	FIL	NP
V307	200K	9K	150K	210K	0	150K	FIL	FIL	NP
V308	0	*	300K	FIL	FIL	0	*	3.6M	300K

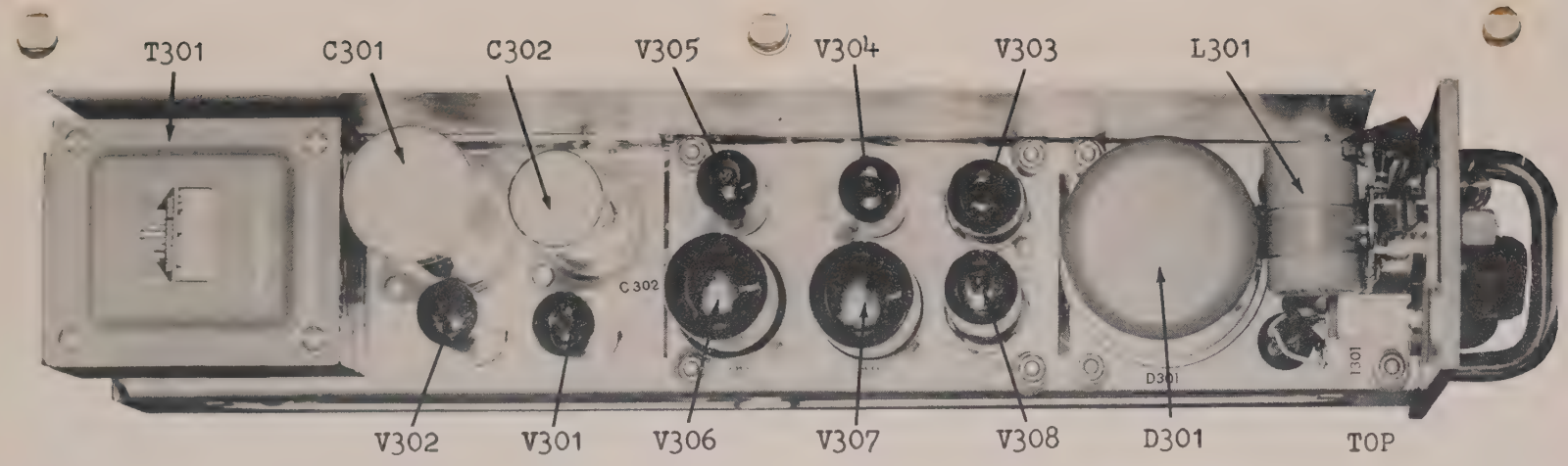
* Do not measure. Bias cell in circuit
NC No connection
NP No pin

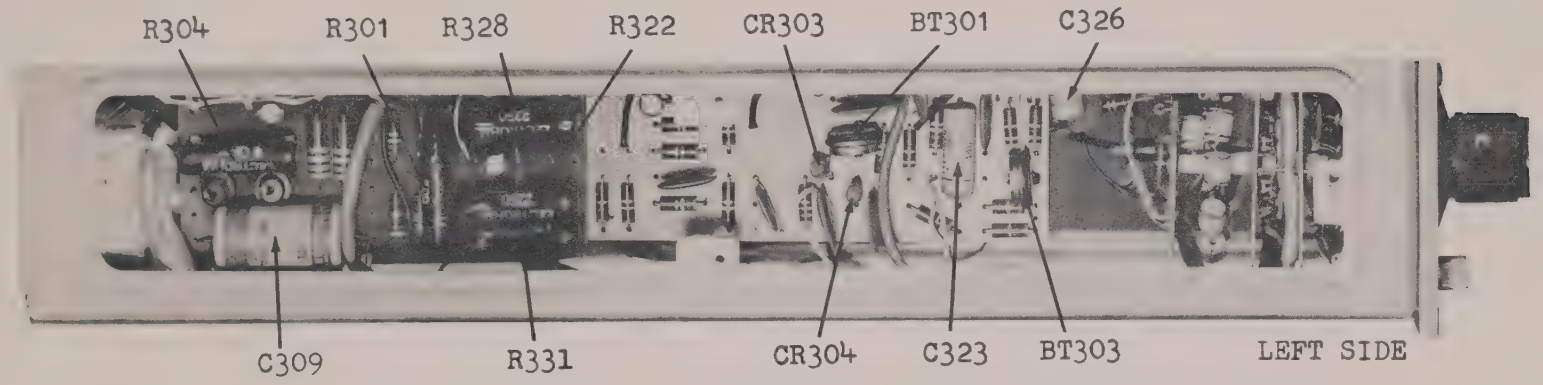
TROUBLE SHOOTING CHART

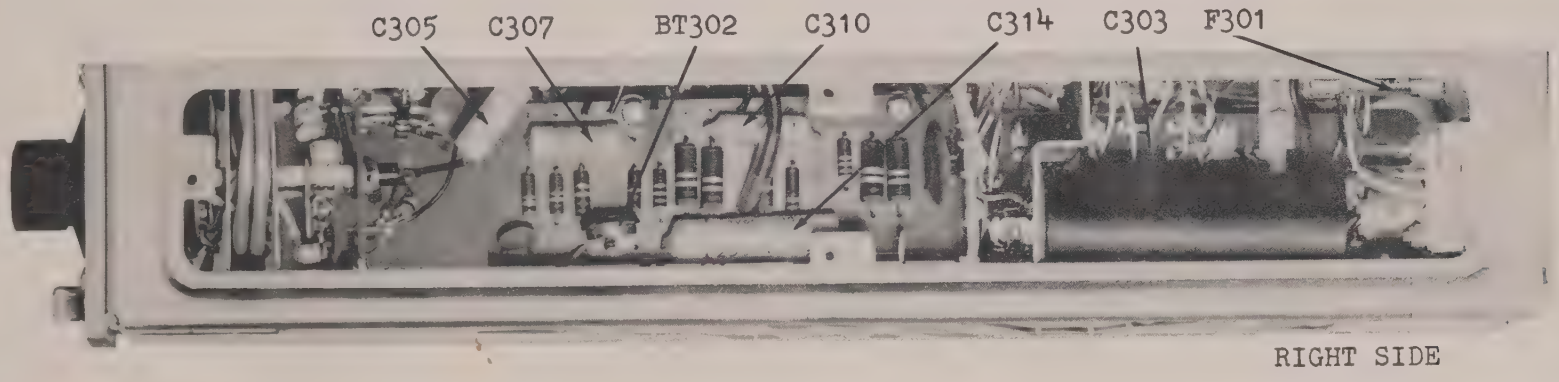
Test conditions
1 - Input connected to test box or short circuited.
2 - 1000 Ω load on output.

CONDITION	TROUBLE	REMEDY
1. Overload lamp on or flashing, at any gain range.	1. V303, V304, V305 or V308 2. ACA or DCA gain incorrect 3. Chopper not demodulating 4. High frequency oscillation	1. Check tube plate voltages 2. Replace bad tubes 3. Replace chopper 4. Replace attenuator
2. 750 cps noise above normal	1. V304 or V303B noisy 2. R353 open 3. CR303 or CR304 open 4. C301A, C301B or C301C open 5. D301 noisy 6. ACA gain low	1. Replace with good tube 2. Replace R353 3. Replace 4. Replace 5. Replace 6. Replace bad tube
3. 3 cps noise above normal	1. Same as above.	
4. Wide band noise above normal	1. C304 open 2. R354 open 3. C308 or C319 open	1. Replace 2. Replace 3. Replace
5. Wide band noise above normal only on some gain ranges	1. C401 thru C410 or R402 thru R410 and R321 defective	1. Replace
6. Gain accuracy at 2 kc incorrect	1. C304 defective V303, V304 or V305 defective 2. DCA gain below normal	1. Replace bad tubes 2. Check tubes and voltages Replace defective tubes or components.

CONDITION	TROUBLE	REMEDY
7. Gain accuracy at DC incorrect	1. R412 thru R422 and R306 and R305 defective	1. Replace
8. Gain accuracy at 10 KC incorrect	1. C304 defective 2. V303, V304, V305 low gain	1. Replace 2. Replace
9. Linearity at 2 kc below normal	1. V306 or V307 defective	1. Replace
10. Output impedance above normal	1. L401 open 2. V303, V304, V305 very low gain	1. Replace 2. Replace
11. Sensitive to line transients	1. V304 filament voltage too high or C303 defective 2. C301 defective	1. Correct error 2. Replace
12. Zero drift above normal	1. V303A or V303B defective 2. D301 defective 3. C308 defective 4. V303B defective	1. Replace 2. Replace 3. Replace 4. Replace
13. No recovery from overload	1. V303B or V308 defective 2. D301 not demodulating 3. C323 or R349 open	1. Replace 2. Replace 3. Replace
14. Incorrect DC balance	1. R333 thru R341 defective 2. D301 defective	1. Replace







111 AMPLIFIER
PARTS LOCATION PHOTOGRAPHS

PARTS LIST

DCDA 111 FINAL ASSEMBLY
(Job #609)

CAPACITORS		KAY LAB PART NO.
C301	ABC 80/40/20mfd 450V Can	
	UPT84245 or FP378 Only	51003
C303	ABC 20/10/10mfd 450V Can	
	UP21145 or 376.3 Only	~~51004~~ 51004
C302	AB 1000/1000mfd 15V	
	UPT201 Only	57310
C304	50mmfd Ceramic Disc	41016
C305	.1mfd 200V Mylar 620	66443
C306	200mmfd Ceramic Disc	41048
C307	.1mfd 200V Mylar 620	66443
C308	3mmfd CS Stackpole	46749
C309	8mfd 150V Tubular	
	BR815 or TC41 Only	51008
C310	.05mfd 400V Mylar 620	65303
C311	.01mfd Ceramic Disc	41056
C312	.01mfd Ceramic Disc	41056
C313	50mmfd Ceramic Disc	41016
C314	.5mfd 200V Mylar 620	65315
C315	.02mfd Ceramic Disc	41058
C316	.01mfd Ceramic Disc	41056
C317	.01mfd Ceramic Disc	41056
C318	.01mfd Ceramic Disc	41056
C319	.01mfd Ceramic Disc	41056
C320	.1mfd 200V Mylar 620	66443
C321	.01mfd Ceramic Disc	41056
C322	.01mfd Ceramic Disc	41056
C323	.1mfd 200V Mylar 620	66443
C324	.01mfd Ceramic Disc	41056
C325	.02mfd Ceramic Disc	41058
C326	.1mfd 200V Mylar 620	66443
C327	50mmfd Ceramic Disc	41016
C328	50mmfd Ceramic Disc	41016
C401	1000mmfd Ceramic Disc	41046
C402	2000mmfd Ceramic Disc	41048
C403	1000mmfd Ceramic Disc	41046
C404	1000mmfd Ceramic Disc	41046
C405	680mmfd Ceramic Disc	41042
C406	200mmfd Ceramic Disc	41027
C407	200mmfd Ceramic Disc	41027
C408	100mmfd Ceramic Disc	41022
C409	100mmfd Ceramic Disc	41022
C410	68mmfd Ceramic Disc	41018
C411	.01mfd " "	41056
C329	.005mfd " "	41054

RESISTORS		KAY LAB PART NO.
R301	500ohm 5w	511995
R302	10K 2w	451793
R303	39K 1w	431570
R304	4ohm 5w	511975
R305	100K 1% [redacted] Dep. Carb.	~~473448~~ 481001
R306	1meg 1% [redacted] Dep. Carb.	~~473481~~ 481002
R307	10K ½w	411333
R308	220K ½w	411349
R309	330K 1w	431581
R310	330K 1w	431581
R311	82K 1w	431574
R312	33K ½w	411339
R313	33K ½w	411339
R314	120K 1w	431576
R315	47K ½w	411341
R316	6.8meg ½w	411367
R317	82K 1w	431574
R318	120K 1w	431576
R319	47K ½w	411341
R320	1meg ½w	411357
R321	1meg ½w	411357
R322	2250ohm 5w	516142
R323	680K ½w	411355
R324	100K ½w	411345
R325	100K ½w	411345
R326	120K ½w	411346
R327	100K ½w	411345
R328	2250ohm 5w	516142
R329	82K ½w	411344
R330	680K ½w	411355
R331	1Kohm 5w	512001
R332	100K ½w	411345
R333	180K ½w	411348
R334	470ohm ½w	411317
R335	470ohm ½w	411317
R336	330K ½w	411351
R337	10K ½w Pot. Screw Driver Slot	501865
R338	6.8meg ½w	411366
R339	5.6meg ½w	411366
R340	10K ½w	411333
R341	6.8meg ½w	411367

PARTS LIST

DCDA 111 FINAL ASSEMBLY
(Job #609)

RESISTORS		KAY LAB PART NO.
R342	22K ½w	411337
R343	680K ½w	411355
R344	1K ½w	411321
R345	10meg ½w	411369
R346	10meg ½w	411369
R347	220K ½w	411349
R348	3.3meg ½w	411363
R349	4.7meg ½w	411365
R350	1meg ½w	411357
R351	220K ½w	411349
R352	3.3meg ½w	411363
R353	1meg ½w	411357
R354	4.7ohm 1w	436744
R355	2.7meg ½w	411362
R356	220K ½w	411349
R357	3.3meg ½w	411363
R358	82ohm ½w	411308
R401	-	
R402	39ohm ½w	411304
R403	120ohm ½w	411310
R404	180ohm ½w	411312
R405	330ohm ½w	411315
R406	680ohm ½w	411319
R407	1.2K ½w	411322
R408	1.8K ½w	411324
R409	2.7K ½w	411326
R410	3.9K ½w	411328
R411	39ohm ½w	411304
R412	4.5Kohm ¼% Cinema 410JE	486796
R413	1.5Kohm ¼% Cinema 410JE	486795
R414	1.2Kohm ¼% Cinema 410JE	486794
R415	514.3ohm ¼% Cinema 410JE	486791
R416	385.7ohm ¼% Cinema 410JE	486790
R417	4.5Kohm ¼% Cinema 410JE	486796
R418	1.5Kohm ¼% Cinema 410JE	486795
R419	1.2Kohm ¼% Cinema 410JE	486794
R420	514.3ohm ¼% Cinema 410JE	486791
R421	385.7ohm ¼% Cinema 410JE	486790
R422	900ohm ¼% Cinema 410JE	486792
R423	1Kohm ¼% Cinema 410JE	486793

TUBES		
V301	6X4	702786
V302	6X4	702786
V303	5751	732812
V304	6AU6 RCA Only	702748
V305	6CB6	702773
V306	6BX7	702768
V307	6BX7	702768
V308	6AW8	707419

MISCELLANEOUS		
CR301	Diode 1N91	356751
CR302	Diode 1N91	356751
CR303	Diode 3U1	356774
CR304	Diode 3U1	356774
BT301	Bias Cell Mallory RM625T	184158
BT302	Bias Cell Mallory RM625T	184158
BT303	Bias Cell Mallory RM625T	184158
D301	Brown Converter SS8899KC	636855
F301	Fuse 3AG 1A Slo Blo	172633
I301	Pilot Lamp #47	174149
I302	Neon Lamp #NE57	174152
L401	Choke 25MH .05ohm Mallory RF581	236773
P-301	Modified 137470 Conn. Cannon Plug DPB-12-34 P1A (Modified	947604 137470
S401	Switch Wafer Centrlab PA-30	616780
	Switch Wafer Centrlab PA-31	616781
	Switch Index Centrlab PA-300	626344
T301	Power Transformer Triad 8428	657574

APPR.		CHANGE	DATE	ORDER
	A	C306 WAS .002; ADDC-329; CHANGE CIRCUIT AT C302	7/12/56	EO 716
	B	R338 WAS 5.6M	7/13/56	EO 775
	C	ADD SHIELDED WIRE FROM PIN 2 V307; ADD C411 AT S401	8/17/56	EO 817

V301 6X4
V302 6X4
V303A ½5751
V304 6AU6
V305 6CB6
V306 6BX7
V307 6BX7
V308 6AW8
V303B ½5751

T301
R301 500 5W
+380V
C301A 20
R302 10K 2W
+320V
C301B 40
R303 39K 1W
+200V
C303 A 20 B 10 C 10
C301C 80
+240V
R304 4.3K 5W
+12V
CR301 IN91
CR302 IN91
+13.2V
C302A 1000
C302B 1000
4.5
C304 50 μμF
F301 3AG 1A SLO-BLO
V301
V302
V307
V306
V305
I301
D301
D301 BROWN 558899KC
R309 330K 1W 5%
+13V
CR303 3U1
CR304 3U1
BT 301 -45V
R310 330K 1W 5%
-13V
R312 33K
R313 33K
C311 .1
C312 .01
R308 220K
R311 82K 1W
R314 220K 1W
C307 0.1
R305 100K 1%
C305 0.1
INPUT
R307 10K
C306 200 μμF
+125V
-1.35V
0V
+185V
+70
C310 .05
-1.8V
R316 6.8M
C309 8
R315 47K
R317 82K 1W
R318 120K 1W
+145V
C313 50 μμF
+74V
C314 0.5
R319 47K
C315 .02
R320 1M
+200V
R322 2250 5W
R323 680K
C316 .01
R325 100K
I302 NE-51
R327 100K
R326 120K
+135V
-10V
-12V
C317 .01
R328 2250 5W
R330 680K
C318 .01
R329 82K
-125V
-115V
C329 .005
R321 1M
R324 100K
R331 1000 5W
-150V
R332 100K
CHASSIS GROUND
R345 10M
R350 1M
BT 302
R358 82
LEAD #1 (SEE NOTE 2)
S401 GAIN
LEAD #2 (SEE NOTE 2)
LEAD #3 (SEE NOTE 2)
-0-
-20-
-30-
-50-
-70-
-100-
-200-
-300
-500-
-700-
-1000-
C411 .01
C401 1000
C402 2000
C403 1000
C404 1000
C406 680
C406 200
C407 200
C408 100
C409 100
C410 68
R402 39
R403 120
R404 180
R405 330
R406 680
R407 1.2K
R408 1.8K
R409 2.7K
R410 39K
L301 25μH/.05Ω
R411 39
R412 4500 ½%
R413 1500 ½%
R414 1200 ½%
R415 514.3 ½%
R416 385.1 ½%
R417 4500 ½%
R418 1500 ½%
R419 1200 ½%
R420 514.3 ½%
R421 385.7 ½%
R422 300 ½%
R423 1000 ½%
R333 180K
-150V
R354 470
R335 470
R336 330K
+0.3V
R337 10K
R338 6.8M
R339 5.6M
R354 4.7
R340 10K
R341 6.8M
R343 680K
R342 2.2K
R344 1K
C320 0.1
C319 .01
INPUT
OUTPUT
C327 50 μμF
C328 50 μμF
R346 10M
R347 220K
+125V
C321 .01
R348 3.3M
BT 303 1.35V
R349 4.7M
R353 1M
C323 0.1 200V
+240V
R351 220K
+90V
C324 .01
C322 .01
R352 33M
R355 2.7M
-1.35V
R356 220K
+135V
C325 .02
+24V
R357 3.3M
C326 0.1
T301

-NOTES-

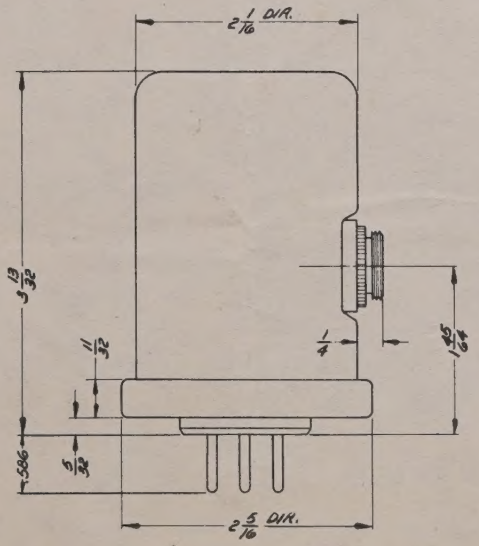
1. ● DENOTES CLOCKWISE ROTATION ON POT.
2. MODIFICATION OF THE STANDARD III DCDA TO CHANGE IT TO AN OPERATIONAL AMPLIFIER MAY BE ACCOMPLISHED ON UNITS WITH SERIAL NUMBERS 1399 OR ABOVE BY CHANGING S401 AS FOLLOWS:
   REMOVE LEAD #1
   REMOVE LEAD #2
   ADD LEAD #3

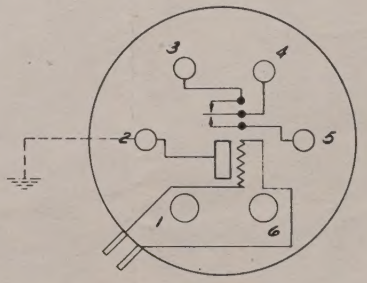
ALL RESISTORS ½ WATT,
ALL RESISTANCES IN OHMS,
ALL CAPACITANCES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED.

DC DECADE AMPLIFIER
MODEL III

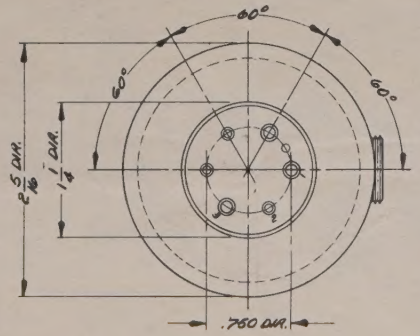
ENGINEER — DRAWN BY — L Hall
DATE — 3-8-56 — CHECKED BY —
SCALE — NONE — DRAWING NO — D307465

KAY LAB
SAN DIEGO 10, CALIF.





BOTTOM VIEW



NOTES:-

1. EXCITATION COIL RATINGS:
   6.3 VOLTS, 60 MILLIAMPERES AT 60 CPS.
2. COIL IMPEDANCE:
   105 OHMS AT 60 CPS.
3. CONTACT RATINGS:
   1 MICROVOLT TO 6 VOLTS MAXIMUM.
   1 MILLIAMPERE MAXIMUM.
   100 MICROWATTS MAXIMUM POWER.
4. PHASE LAG: 17° ± 5°
5. CONTACT TIME: 55% NOMINAL
   SHORTING TIME: 5% TWICE EACH CYCLE.
6. MOUNTING:
   VERTICAL MOUNTING OR HORIZONTAL
   IF PINS 1 AND 4 ARE IN VERTICAL PLANE.
7. CONNECTIONS:
   BASE: FITS STANDARD 6 PIN TUBE SOCKET.
   SIDE: AMERICAN PHENOLIC CORP.
   CAT. NO. 80-PC2M PLUG.

1.	12-30-57			

FORM NO. F-2145-A D.E. 3002-11A

ISSUE NO. APP

APP. FOR RELEASE	ENGR.	DATE	
	SECT. HD.	DATE	
APP. FOR VENDORS QUOTATION	ENGR.	DATE	
	SECT. HD.	DATE	

a	b	c	d	e	f	g	h	i
M-H								
TORONTO								
LONDON								

REPRODUCTION LOCATED AT ; JOB NOS. ; USED ON

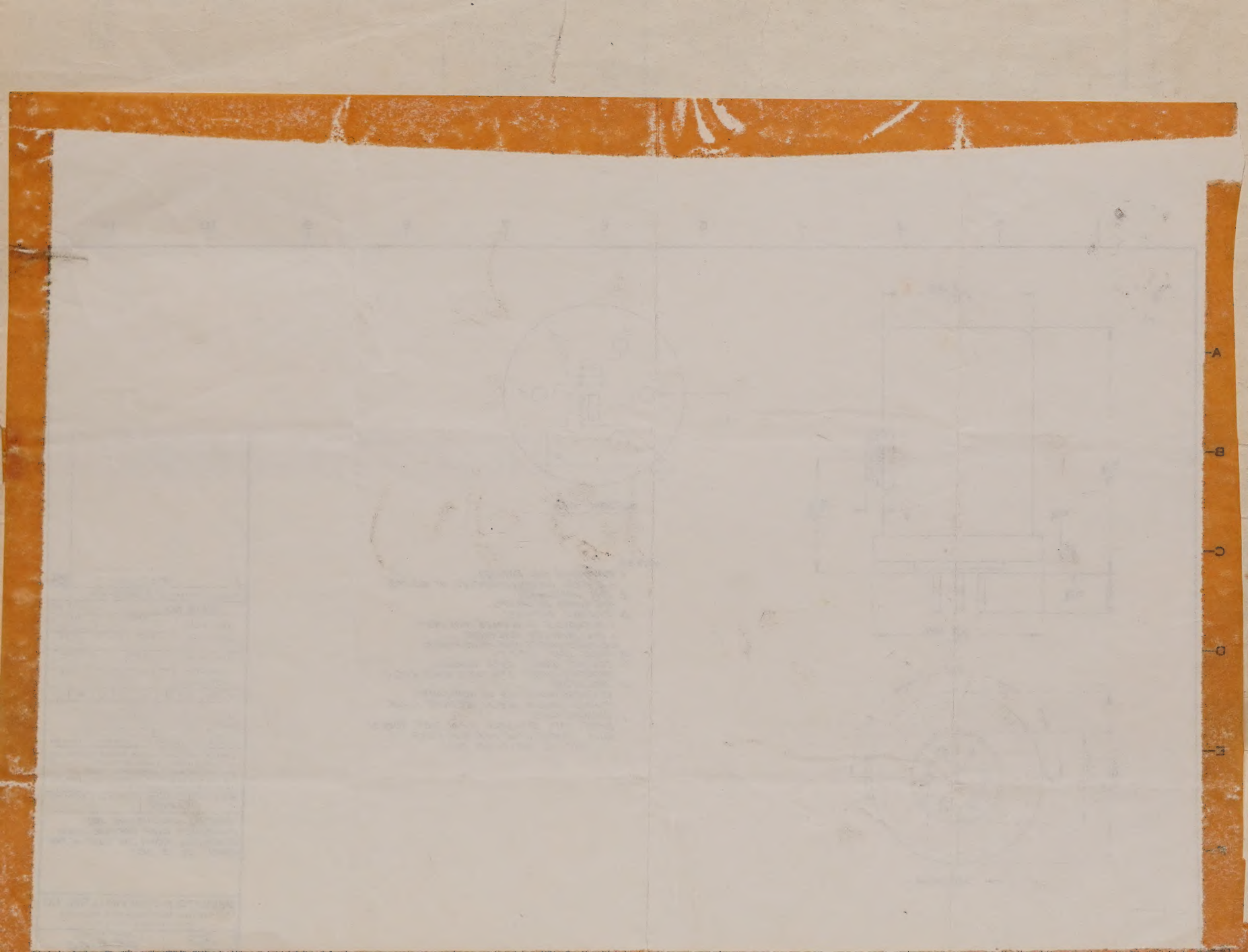
LIMITS --ON DIMENSIONS WHERE LIMITS ARE NOT SHOWN USE THE FOLLOWING
ON ALL DECIMAL DIMENSIONS .005
ON ALL OTHER LINEAR DIMENSIONS 1/64
ANGULAR DIMENSIONS 1

DES. ENGR.	DRAWN	CHECKED	APPROVED
	FRANZ		

OVERALL DIMENSIONS FOR CONVERTER WITH THE COIL LEADS EMERGING FROM THE SIDE OF THE COVER CL. 15 INST.

MINNEAPOLIS-HONEYWELL REG. CO.
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA. U.S.A.

SCALE	DRAWING NO.
1"=1"	25-G-64
DATE	



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